Evaluation of Selected Rocky Flats Environmental Technology Site Operable Unit 2 Storm-Water Radiochemistry for May 1995

November 8, 1995

PREPARED BY:

RMRS Rocky Mountain Remediation Services, L.L.C.
... protecting the environment
Sitewide Surface Water

DOCUMENT CLASSIFICATION
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CLASSIFICATION OFFICE

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11/8/95

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SUMMARY

Radiochemical results were evaluated for storm-water runoff samples collected from hillside locations adjacent to and southeast of Operable Unit 2 (OU2). Radiochemistry for these storm-water samples showed levels of plutonium and americium which decreased rapidly with distance from the top of the hillside at OU2. Plutonium and americium activities varied from 250 pCi/L (Pu) and 50 pCi/L (Am) near the top of the hillside to roughly 4 pCi/L (Pu) and 0.5 pCi/L (Am) below and near the SID. Activities decreased roughly two orders of magnitude between samples collected from the top and bottom of the hillside. The overland flow traveled in a generally southerly direction down the hillside and eventually entered the South Interceptor Ditch (SID). Results show that plutonium and americium are mobilized during overland or surficial flow conditions. However, the relative contribution of plutonium from this study area to overall waterborne plutonium loading in the entire basin is unclear. Implications of these runoff results for plutonium and americium transport to Pond C-2 are also discussed.

The runoff from the OU2 hillside eventually reached Pond C-2 which was discharged to the Broomfield Diversion Ditch from May 18 to June 11, 1995. The Broomfield Diversion Ditch routes the flow away from public drinking water supplies. While the water discharged exceeded the Site-specific 30-day-average discharge standard of 0.05 pCi/L plutonium, there was no danger to public health as gross alpha activities were below Colorado's drinking water standard of 15 pCi/L.

INTRODUCTION

Spring storms producing overland flow conditions provided a rare opportunity to evaluate the mobility of surficial contamination (plutonium and americium[1]) in a region downgradient of OU2 at the Rocky Flats Environmental Technology Site (Site). This report provides a preliminary evaluation of radioanalytical results from storm-water runoff samples collected downgradient from the 903 Pad and Lip Area of OU2 (Figure 1) during a 15-year rainfall event[2] which occurred May 16-17, 1995.

[1] Plutonium and americium herein refer to plutonium-239,240 and americium-241 activities as measured by alpha spectrometry.

[2] M. E. Smith, U.S. Geological Survey, oral communication, May 1995.

The Site had received considerable precipitation prior to the May 16-17 event (Figure 2) that created saturated-soil conditions prior to May 16th. Then, beginning May 16th, the Site received an additional 3.58 inches of rain in 15 hours (Figure 2). The rainfall was intense at times and produced flooding in many Site drainages. During this time, Site environmental scientists participating in the OU2 Soils Study Project observed and sampled rare surficial (overland) flow for radionuclides in OU2, 903 Pad and Lip Area, and on the hillside to the southeast of the 903 Pad. The surficial runoff from the hillside flowed predominantly north to south and eventually entered the South Interceptor Ditch (SID).

SAMPLE COLLECTION

Opportunistic sampling of the runoff was performed at locations shown in Figure 3. Sampling was performed with minimal attention to experimental design (due to time constraints placed by the storm event), and without formal quality assurance samples being collected. Samples were collected by bailing the runoff from shallow gullies using a polyethylene sample bottle with its top cut off. Samples were preserved and shipped according to standard Site protocols, and submitted for plutonium and americium analyses.[3] The analytical results for these samples are shown in Attachment 1. No other water-quality parameters were determined for correlation with the radionuclide activities.

DATA EVALUATION AND INTERPRETATION

Interpretation of radiochemistry in the OU2 runoff on May 17, 1995 is challenged by the absence of corresponding water-quality (e.g., total suspended solids (TSS)) and flow data to complement the radionuclide measurements. A correlation of TSS concentrations and radionuclide activities would have provided a measure of the transport efficiency of soil materials (potentially eroded from the top of the hillside), as well as linked radionuclide activity with suspended solids concentrations. Instead, observation of the geographical distribution of the results, together with general reconnaissance of the study area and a detailed knowledge of historical, basin-wide storm-water quality information were used to evaluate the present OU2 storm-water results. OU2 hillside radiochemistry is also evaluated in relation to observed storm-water quality information for the SID and Pond C-2 — both located downstream from the OU2 study area.

[3] The bailed samples were placed in 1-liter polyethylene containers and acidified with nitric acid to pH less than 2.0. The samples were shipped to Thermo Analytical (TMA) in Richmond, California for analysis of total plutonium-239,240 and americium-241 by alpha spectrometry.

The observed plutonium and americium activities in runoff from the OU2 hillside varied from maxima of 250 pCi/L (Pu) and 50 pCi/L (Am) near the top of the hillside to minima of roughly 4 pCi/L (Pu) and 0.5 pCi/L (Am) below and near the SID (Figure 3). Activities decreased roughly two orders of magnitude between samples collected from the top and bottom of the hillside leaving approximately 5 pCi/L (Pu) entering the SID. Given the dynamic nature of the runoff process, these results indicate that at least some plutonium transport does indeed occur in this area under surficial flow conditions. Unfortunately, the absence of detailed knowledge of the storm-water flows on the hillside precludes a determination of the cause(s) of declining activities from top to bottom of the hillside. Two likely causal factors are: (1) mixing with dilute surficial flows lower on the hillside, and (2) radionuclide re-deposition. Both are discussed below.

Historical data for plutonium and americium in surficial soils in the hillside area show a trend toward decreasing activity with downgradient distance from the 903 Pad Area (Attachment 2)[4]. Assuming a relatively constant fraction of surficial radionuclide activity is available for mobilization in storm water, runoff from less contaminated soils (on the lower portion of the hillside) would tend to dilute higher concentrations from above and result in a trend to lower radionuclide levels from top to bottom of the hillside area. Since plutonium occurs substantially as potentially settleable, particulate or particulate-associated materials (e.g., attached to soil particles) in the environment[5,6,7], actinide material associated with the overland flow may be weakly transported and re-deposited, depending on flow conditions, on the way to the SID. This re-deposition process would result similarly in declining activities in runoff that diminish with downhill distance.

There are other tributaries to the SID in which elevated plutonium activities have been measured in storm-water runoff, although not for the May 17th storm. These locations include gaging stations GS21 and GS24, both located on the 881 Hillside and receiving runoff from waste storage areas (Attachments 5 & 6). By contrast, several storm-water samples from gaging stations GS22 and GS25 (runoff from the Building 460 Area and the east side of Building 881, respectively) do not contain elevated radionuclide activity and indicate these drainage areas are

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[4] Litaor, M.I., Thompson, M.L., Barth, G.R., and Molzer, P.C., November-December 1994, "Plutonium-239,240 and Americium-241 in Soils East of Rocky Flats, Colorado," in *J. Envir. Qual.*, **1994**, *23*, 1231-1239.

[5] Hanson, Wayne C., Ed., Selected Papers in "Transuranic Elements in the Environment," DOE/TIC-22800, Technical Information Center/U.S. Department of Energy, pp. 619-721 (1980).

[6] Harnish, R.A., McKnight, D.M., Ranville, J.F., Stephens, V.C., and Orem, W., "Particulate, Colloidal, and Dissolved-Phase Associations of Plutonium, Americium, and Uranium in Water Samples from Well 1587, Surface Water SW051, and Surface Water SW053 at the Rocky Flats Plant, Colorado," 29 pp. In Press.

[7] White, M.G., and Dunaway, P.B., Eds., Selected Papers in "Transuranics in Natural Environments," Nevada Ecology Group, U. S. Energy Research and Development Administration, Las Vegas, Nevada, pp.449-487 (1977).

not significant actinide sources to the SID. Another tributary suspected of contributing plutonium activity in storm-water runoff is a gully which flows intermittently from station SW055 south to the SID (Figure 1). Samples of this tributary were not available for the May 16-17 event. Total plutonium and americium activities for storm-water samples obtained from the OU2 drainage (May 17, 1995); gaging station SW027 (May 16 and 27, June 28, 1995); and Pond C-2 (May 18-19, May 20-26, and May 27 - June 2, 1995) are summarized in Figure 4.

Elevated plutonium levels in Pond C-2 measured on May 18, May 23, and May 30, 1995 (Attachment 3) also support the transport of plutonium from upgradient sources at the OU2 hillside and/or other SID tributaries. Plutonium and americium appear regularly at slightly elevated levels (0.3-2.3 pCi/L) in storm-water runoff samples collected at gaging station SW027, located at the east end of the SID before it enters Pond C-2 (See Attachment 4). Increases in plutonium levels in Pond C-2 appear also to have a temporal link to the upstream runoff from the OU2 hillside study area as well as other tributaries. This connection suggests that the OU2 study area is a possible contributor to storm-waterborne radionuclides in this basin, although its relative contribution to the total radionuclide storm-water loading in the basin remains unclear.

Alternatively, the elevated radionuclide levels in Pond C-2 might have, as their source, the flushing of radionuclides previously accumulated from the hillside *and/or* other diffuse sources in the SID drainage. Once accumulated, this material could be periodically flushed into Pond C-2, particularly during storms of the magnitude experienced on May 17th. Whatever the upstream source(s), an upper estimate of the plutonium activity transported to Pond C-2 may be calculated from radiometric and volumetric data for the pond. May-June 1995 water-monitoring records for Pond C-2 show a maximum activity of 0.30 pCi/L (Pu) for May 18th (Attachment 3) and total volumetric accumulation of 25.0 million gallons. Using these values and assuming a uniform distribution of radionuclides and no prior settling or re-deposition, the maximum activity transported to Pond C-2 is estimated to be 29 μCi (Pu). Waterborne activity diminished with time to 0.10 pCi/L (Pu), and water-quality was apparently improved by controlled detention in Pond C-2 prior to discharge.

Because of the potential for transport of radionuclides to offsite watersheds, radiochemical results for water in Pond C-2 and SW027 were previously reported to downstream communities, the State of Colorado, and other stakeholders as they became available on June 28, 1995 and July 25, 1995. Water discharged from Pond C-2 on May 18-June 11, 1995 exceeded the Site-specific 30-day-average discharge standard of 0.05 pCi/L plutonium[8]. The Pond C-2 water was

[8] Measured plutonium values ranged from 0.105 to 0.298 pCi/L.

discharged to the Broomfield Diversion Ditch which routes the flow away from public drinking water supplies. There was no danger to public health as gross alpha activities were below Colorado's drinking water standard of 15 pCi/L.

CONCLUSIONS

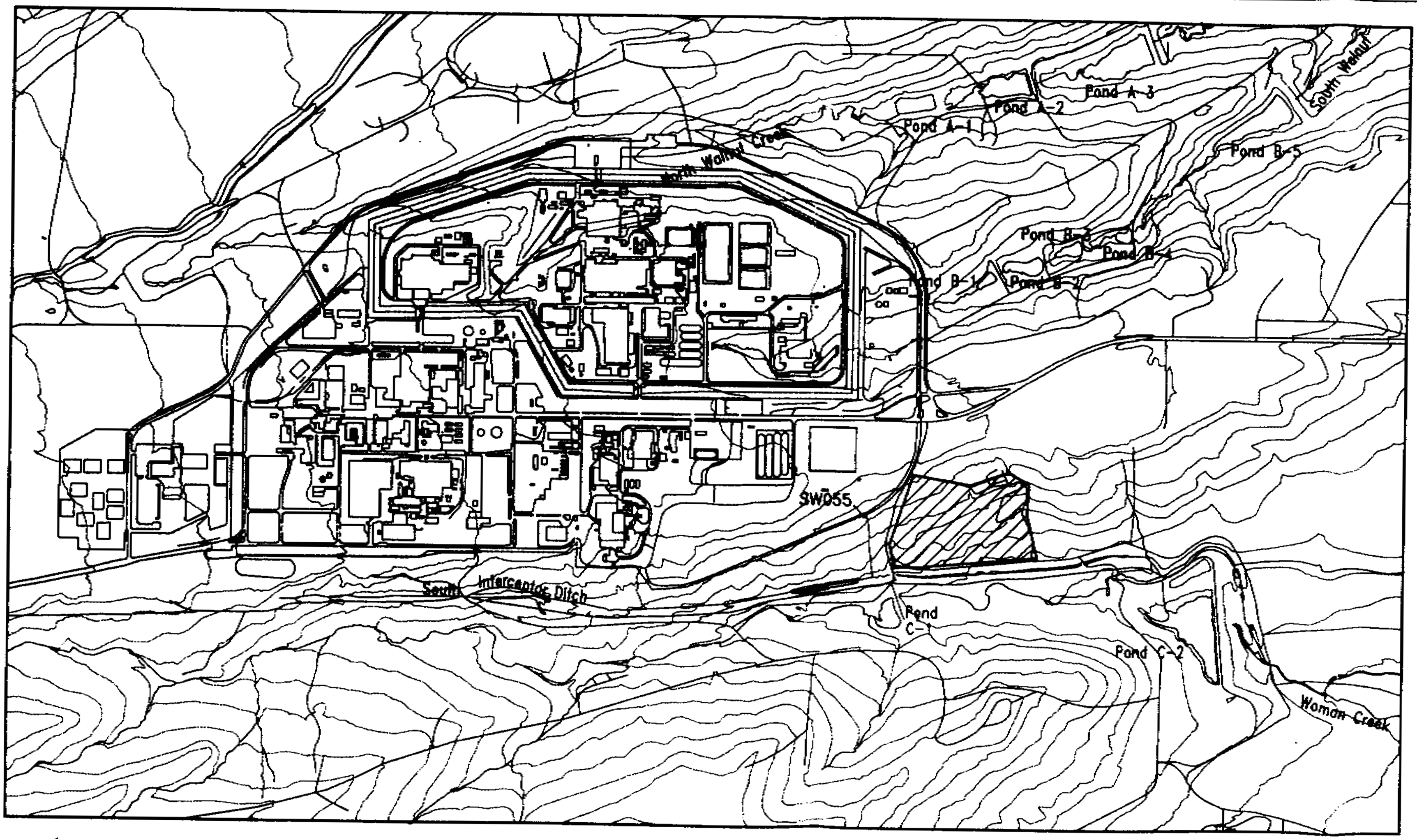
The evaluation of radiochemistry in runoff from the May 16-17, 1995 event, when placed in perspective by historical water-quality information and other sitewide storm-event monitoring efforts, suggests the following conclusions:

1. Actinides (plutonium and americium) deposited on the OU2 hillside can be transported downgradient during overland (i.e., surficial) flow conditions.
2. Observed plutonium and americium activities in runoff from the OU2 hillside varied from maxima of 250 pCi/L (Pu) and 50 pCi/L (Am) near the top of the hillside to minima of roughly 4 pCi/L (Pu) and 0.5 pCi/L (Am) below and near the SID.
3. Actinide activities in runoff declined from top to bottom of the hillside as a result of either dilution and/or re-deposition, but the dominant mechanism(s) for the decline remains elusive without supporting (TSS and flow) information.
4. The OU2 runoff from the May 16-17, 1995 event probably accounts for some of the variation in plutonium activity measured in Pond C-2 in May 1995, but the relative contribution of the OU2 runoff to basin-wide plutonium loading is unclear.
5. These OU2 runoff results provide additional evidence that the 903 Pad and surrounding area should continue to be a high priority for accelerated remedial action.

RECOMMENDATIONS

Samples of the OU2 overland runoff were collected as ad-hoc samples during an unusual precipitation event and as part of a research study to characterize the fate and transport of plutonium in OU2 soils. If a determination of the relative contributions of actinides from different sub-basins within the SID drainage is needed, then a complete loading analysis of the SID is recommended. The loading analysis would require simultaneous measurement of flow and water quality in each major SID tributary to compute actinide loadings. Such a loading analysis of the SID would require a minimal but longer-term (perhaps seasonal) commitment of resources to secure sufficient opportunities to observe infrequent soil-saturation and storm conditions favoring overland runoff.

FIGURES



U.S. DEPARTMENT OF ENERGY

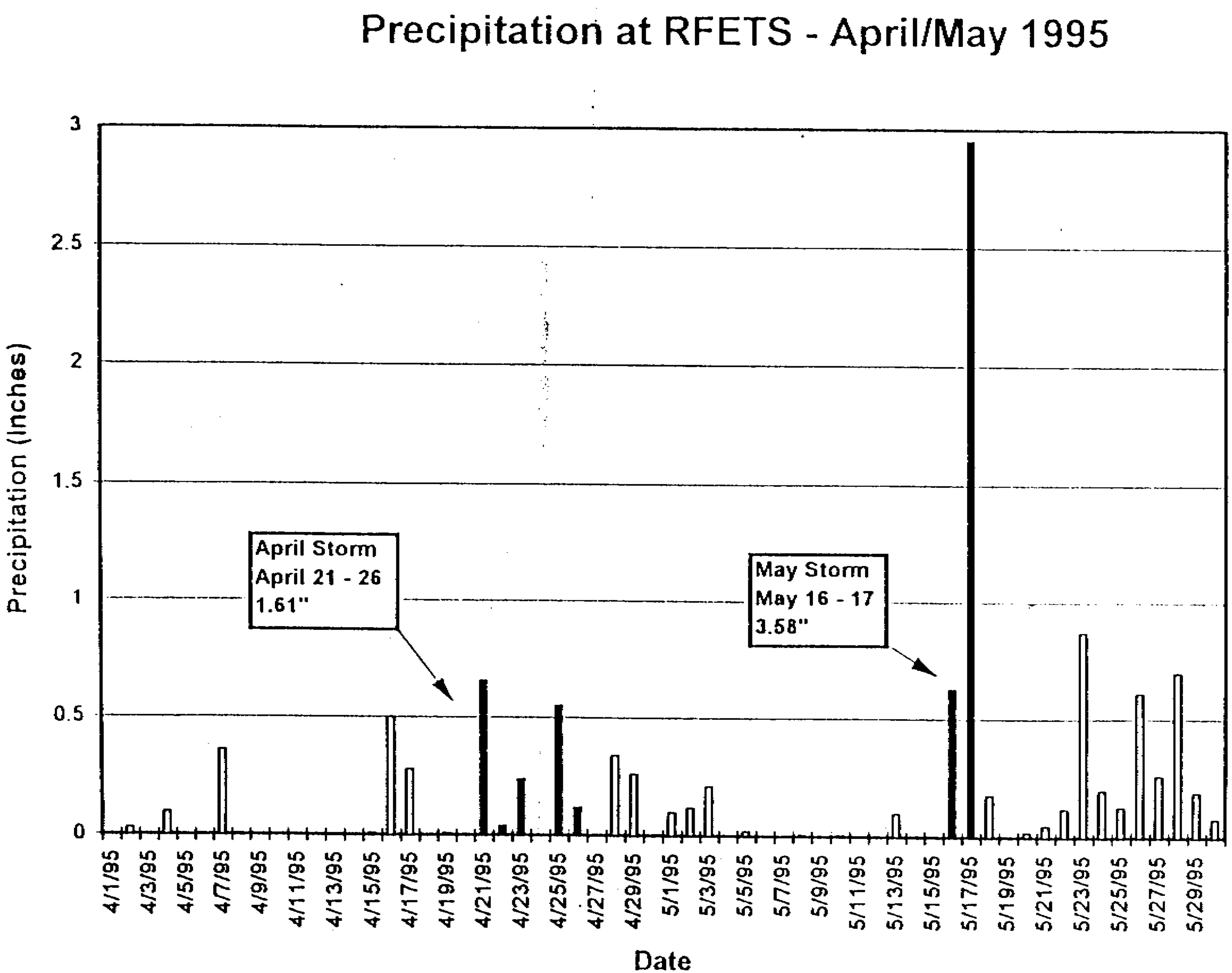
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Ponds and Lakes
Buildings
Streams and Drainages
Roads and Fences
Contour Lines
OU2 STUDY AREA

ROCKY MOUNTAIN REMEDIATION SERVICES L.L.C.

FIGURE 1

Figure 2



Precipitation at RFETS - April/May 1995
Precipitation (Inches)
3
2.5
2
1.5
1
0.5
0
April Storm
April 21 - 26
1.61"
May Storm
May 16 - 17
3.58"
4/1/95
4/3/95
4/5/95
4/7/95
4/9/95
4/11/95
4/13/95
4/15/95
4/17/95
4/19/95
4/21/95
4/23/95
4/25/95
4/27/95
4/29/95
5/1/95
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5/11/95
5/13/95
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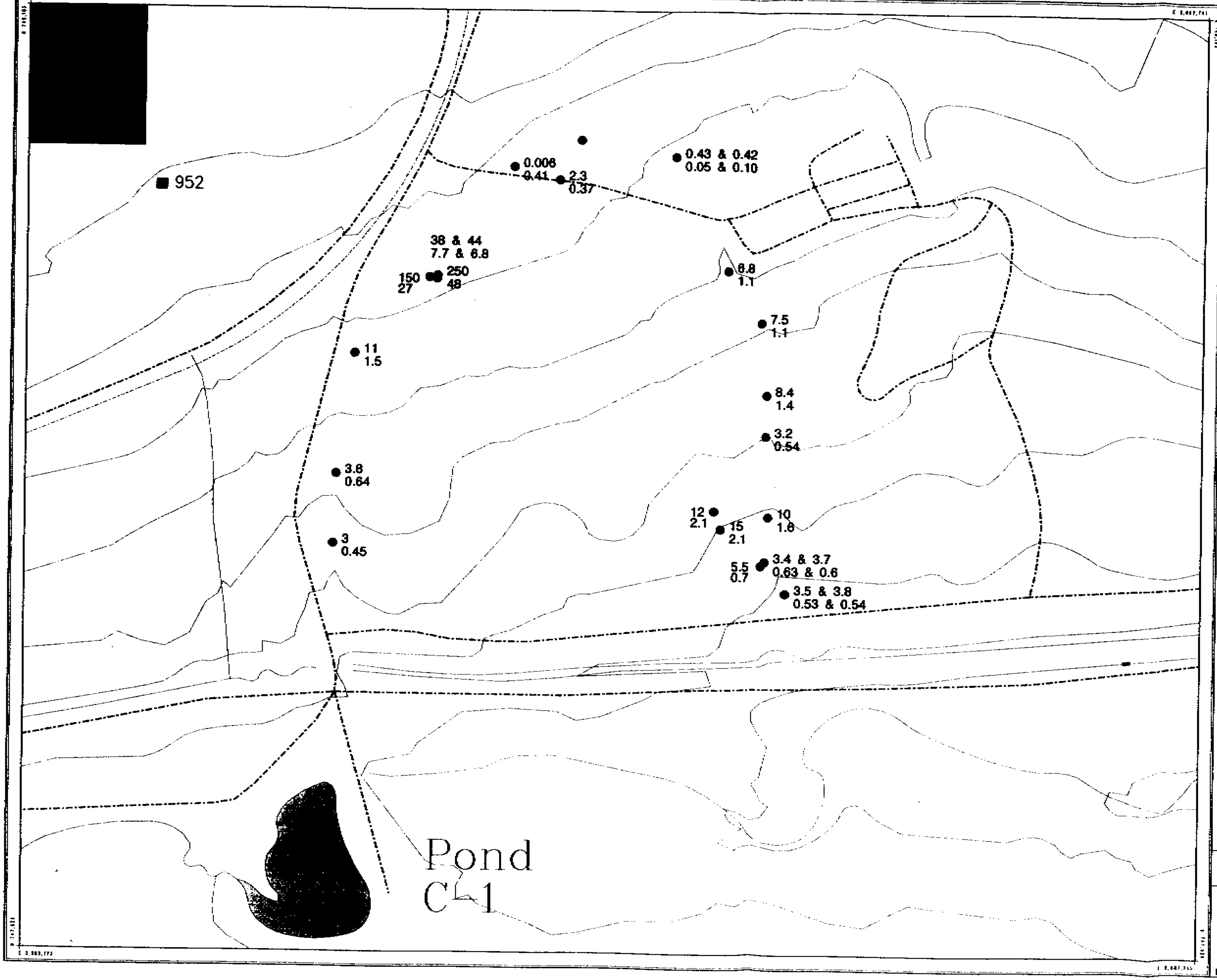
5/27/95
5/29/95
Date



Storm Event Sampling Locations

Figure 3

EXPLANATION

- ● Storm Event Sampling Locations
- ● Plutonium (Units in (pCi/l)
- ● Americium (Units in (pCi/l)
- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Eng., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)
Storm Event Sampling Data provided by Michael Ulmer of EG&G Rocky Flats - May 1995.

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Scale = 1 : 1890
1 inch represents approximately 157.5 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.

MAP ID: ***Draft***

October 31, 1995

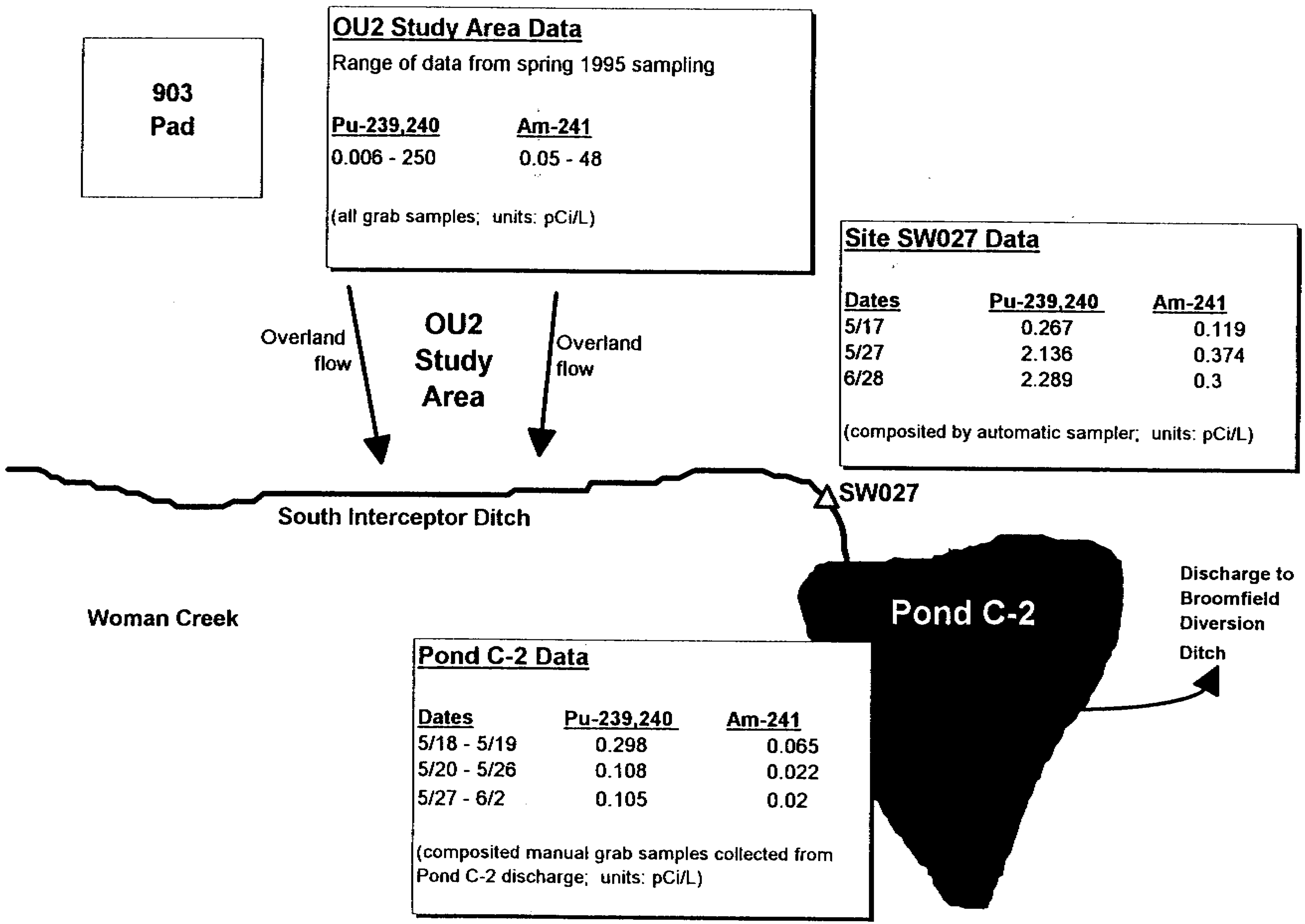


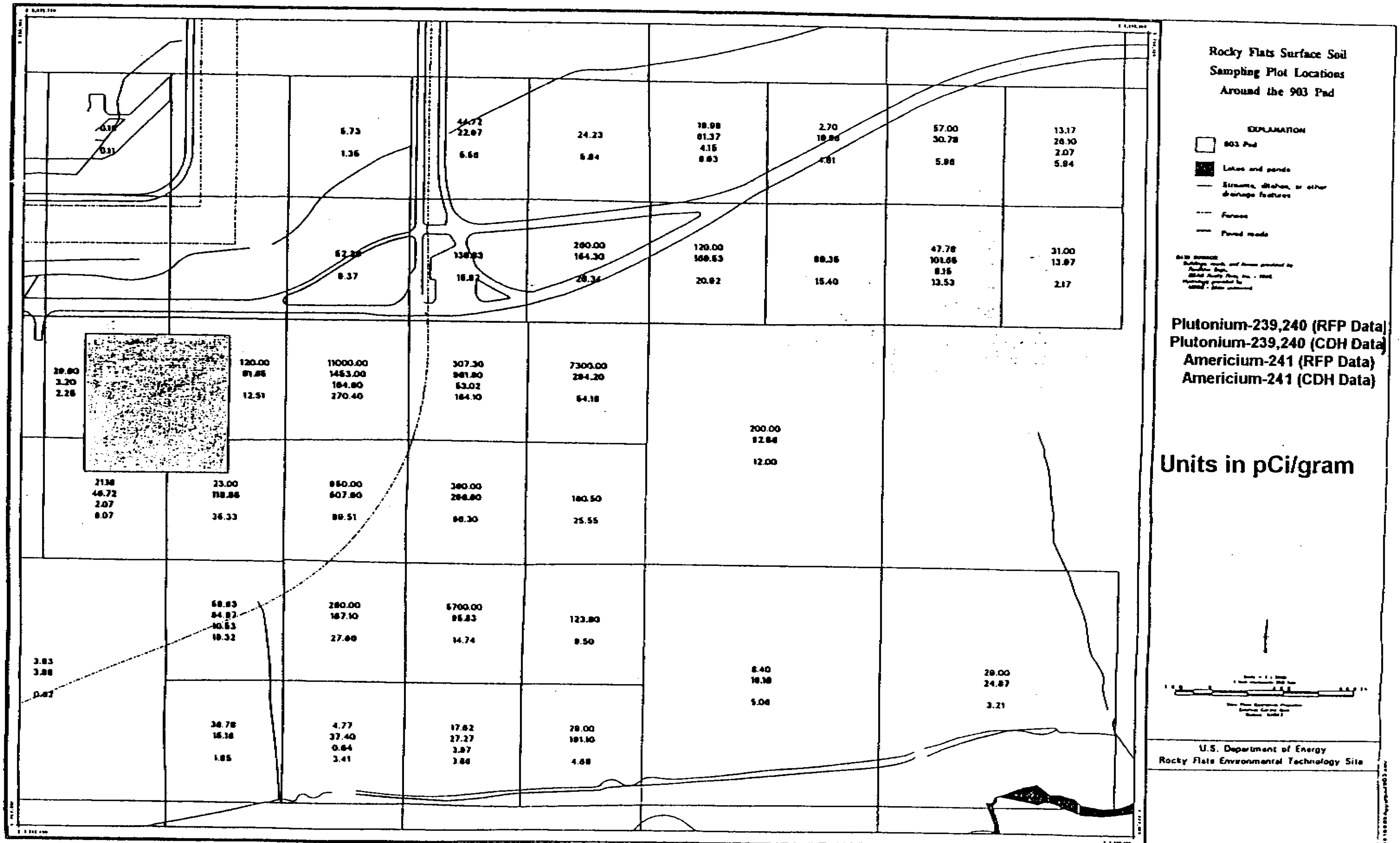
Figure 4. Schematic of May and June 1995 storm event samples in the vicinity of OU2.

ATTACHMENTS

Attachment 1. Radioanalytical Results for OU2 Hillside Runoff for May 17, 1995

Location	Sample Number	Analyte	Result	Error	Unit	Detect Limit
SW30195	SW00101ST	Pu-239/240	3.5	0.32	PCI/L	0.03
SW30195	SW00101ST	Pu-239/240	3.8	0.28	PCI/L	0.04
SW30195	SW00101ST	Am-241	0.53	0.053	PCI/L	0.04
SW30195	SW00101ST	Am-241	0.54	0.053	PCI/L	0.04
SW30295	SW00102ST	Pu-239/240	3.4	0.28	PCI/L	0.03
SW30295	SW00102ST	Pu-239/240	3.7	0.28	PCI/L	0.02
SW30295	SW00102ST	Am-241	0.63	0.059	PCI/L	0.02
SW30295	SW00102ST	Am-241	0.6	0.059	PCI/L	0.03
SW30395	SW00103ST	Pu-239/240	10	0.7	PCI/L	0.05
SW30395	SW00103ST	Am-241	1.6	0.1	PCI/L	0.02
SW30495	SW00104ST	Pu-239/240	3.2	0.33	PCI/L	0.05
SW30495	SW00104ST	Am-241	0.54	0.04	PCI/L	0.01
SW30595	SW00105ST	Pu-239/240	8.4	0.74	PCI/L	0.04
SW30595	SW00105ST	Am-241	1.4	0.15	PCI/L	0.04
SW30695	SW00106ST	Pu-239/240	7.5	0.68	PCI/L	0.04
SW30695	SW00106ST	Am-241	1.1	0.1	PCI/L	0.02
SW30795	SW00107ST	Pu-239/240	6.8	0.69	PCI/L	0.05
SW30795	SW00107ST	Am-241	1.1	0.098	PCI/L	0.02
SW30895	SW00108ST	Pu-239/240	5.5	0.49	PCI/L	0.05
SW30895	SW00108ST	Am-241	0.7	0.059	PCI/L	0.04
SW30995	SW00109ST	Pu-239/240	15	0.93	PCI/L	0.03
SW30995	SW00109ST	Am-241	2.1	0.19	PCI/L	0.03
SW31095	SW00110ST	Pu-239/240	12	0.76	PCI/L	0.02
SW31095	SW00110ST	Am-241	2.1	0.24	PCI/L	0.05
SW31195	SW00111ST	Pu-239/240	3.8	0.31	PCI/L	0.03
SW31195	SW00111ST	Am-241	0.64	0.039	PCI/L	0.008
SW31295	SW00112ST	Pu-239/240	3	0.23	PCI/L	0.02
SW31295	SW00112ST	Am-241	0.45	0.033	PCI/L	0.02
SW31395	SW00113ST	Pu-239/240	11	1	PCI/L	0.07
SW31395	SW00113ST	Am-241	1.5	0.15	PCI/L	0.03
SW31495	SW00114ST	Pu-239/240	250	22	PCI/L	0.1
SW31495	SW00114ST	Am-241	48	5.1	PCI/L	0.5
SW31595	SW00115ST	Pu-239/240	150	15	PCI/L	0.08
SW31595	SW00115ST	Am-241	27	3.1	PCI/L	0.1
SW31695	SW00117ST	Pu-239/240	44	3.4	PCI/L	0.06
SW31695	SW00116ST	Pu-239/240	38	3.4	PCI/L	0.04
SW31695	SW00117ST	Am-241	7.7	0.58	PCI/L	0.06
SW31695	SW00116ST	Am-241	6.8	0.24	PCI/L	0.02

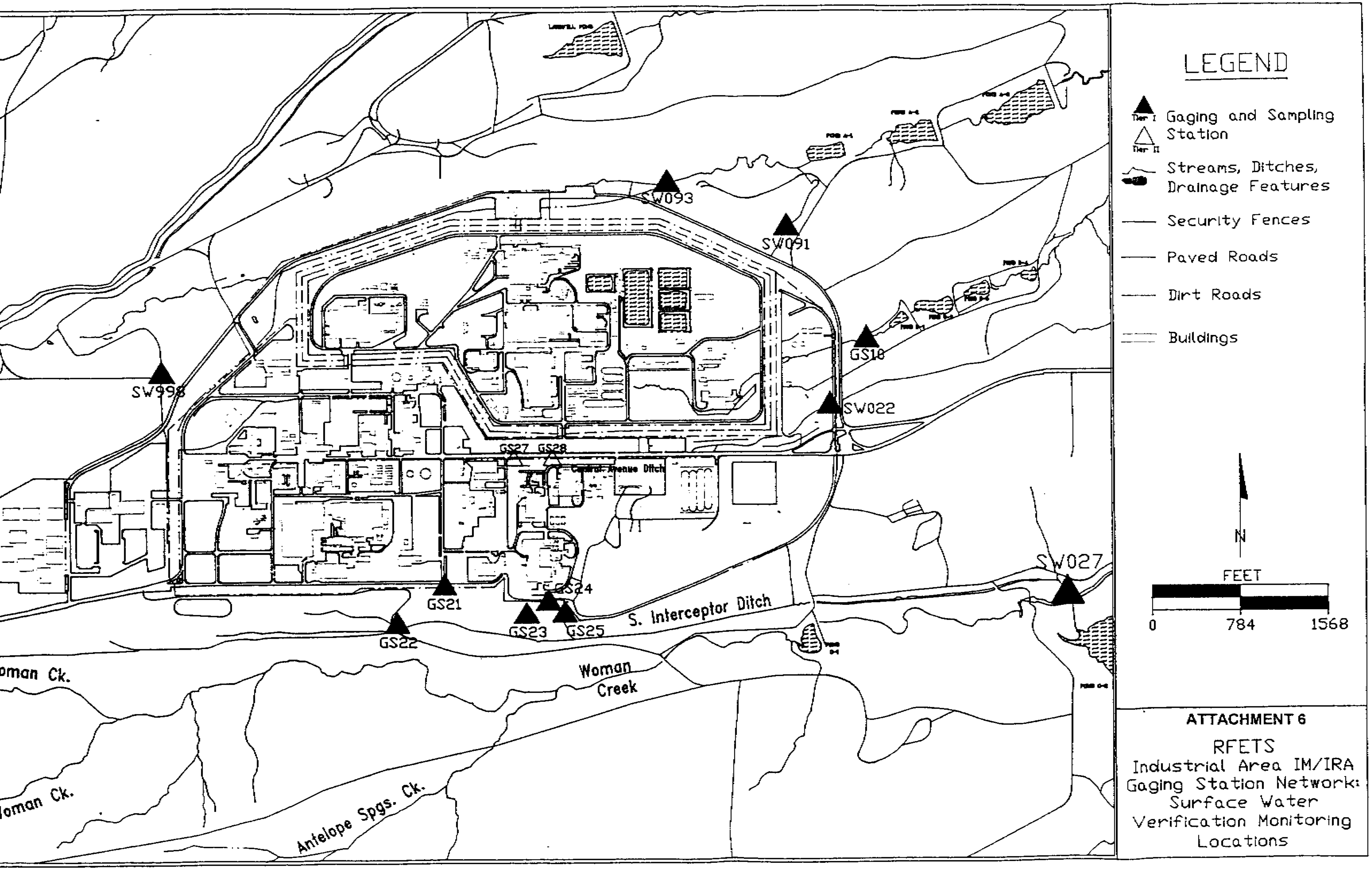
ATTACHMENT 2



ATTACHMENT 3

Location	Composite Period	Mid-Date, Composite	Pu-239-240	Pu, Std. Dev.	Am-241 (pCi/L)	Am, Std. Dev.	U-233,234 (pCi/L)	U-233,234, Std. Dev.	U-238 (pCi/L)	U-238, Std. Dev.	TSS, min	TSS, max	Gross Alpha, max (pCi/L)	Gross Alpha, Std. Dev.	Gross Beta, max (pCi/L)	Gross Beta, Std. Dev.
Pond C-2	5/18/95-5/19/95	5/18/95	0.298	0.063	0.065	0.022	1.02	0.21	1.41	0.28	18	27	3	1	7	2
	5/20/95-5/26/95	5/23/95	0.108	0.028	0.022	0.012	1.15	0.15	1.6	0.2	9	10	5	2	8	3
	5/27/95-6/2/95	5/30/95	0.105	0.018*	0.02	0.009	1.27	0.14	2.11	0.22	11	18	3	2	6	2
Volume Weighted Average			0.121	0.016	0.024	0.007	1.19	0.09	1.82	0.14						

* - Result is reported as conditional; sample recovery is less than QA requirements. All other QA acceptable.



ATTACHMENT 6

RFETS
Industrial Area IM/IRA
Gaging Station Network:
Surface Water
Verification Monitoring
Locations

ATTACHMENT 4

Industrial Area IM/IRA Storm Water Runoff (pCi/L)

Station	Sample Number	Date	Time	Pu-239,240	EPu-239	Am-241	EAm-241	U-233,234	EU-233,234	U-238	EU-238	Gross Alpha	Error Gross Alpha	Gross Beta	Error Gross Beta
SW027	SW00312EG	950517	310	0.267	0.018	0.119	0.014	0.787	0.048	0.858	0.051	6	2	9	2
SW027	SW00325EG	950527	51	2.136	0.085	0.374	0.029	2.505	0.097	5.056	0.178	13	3	10	4
SW027	SW00338EG	950628	2054	2.289	0.09	0.3	0.023	1.991	0.085	3.253	0.127	11	2	10	1

EPu-239,240 = Error term for Pu-239,240 analysis; EAm-241 = Error term for Am-241 analysis, etc. Data are preliminary and subject to revision.

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ATTACHMENT 5

Industrial Area IM/IRA Storm Water Runoff (pCi/L)

Station	Sample Number	Date	Time	Pu-239,240	EPu-239	Am-241	EAm-241	U-233,234	EU-233,234	U-238	EU-238	Gross Alpha	Error Gross Alpha	Gross Beta	Error Gross Beta
GS21	SW00308EG	950503	1639	0.104	0.014	0.013	0.006	0.129	0.019	0.112	0.018	4	1	5.5	2
GS21	SW00313EG	950516	2059	0.031	0.006	0.062	0.009	0.363	0.026	0.486	0.031	6	2	10	2
GS21	SW00327EG	950531	1634	0.004	0.003	0.017	0.004	0.124	0.014	0.072	0.011	7	2	16	2
GS21	SW00339EG	950628	1548	0.045	0.007	0.021	0.005	0.269	0.021	0.17	0.016	7	2	18	2
GS22	SW00307EG	950503	1341	0.007	0.005	0.018	0.008	0.718	0.054	0.67	0.055	4	1	7	2
GS22	SW00314EG	950516	1851	0.027	0.006	0.064	0.011	0.198	0.018	0.172	0.016	2	1	8	2
GS22	SW00328EG	950531	1633	0.002	0.002	0.007	0.004	0.227	0.018	0.247	0.019	6	1	16	2
GS22	SW00340EG	950628	1547	0.008	0.003	0.009	0.004	0.325	0.024	0.261	0.021	5	1	15	2
GS23	SW00331EG	950617	657	0.013	0.004	0.453	0.016	2.599	0.108	0.963	0.051	4	1	5	1
GS24	SW00306EG	950502	1916	0.128	.	0.04	.	1.952	.	0.683	.	18	4	26	3
GS24	SW00318EG	950516	2048	0.025	0.005	0.015	0.004	0.799	0.042	0.297	0.022	10	2	14	2
GS24	SW00341EG	950628	1549	0.209	0.016	0.048	0.015	1.138	0.056	0.623	0.037	19	5	34	3
GS25	SW00305EG	950502	1917	0.036	.	0.012	.	3.5	.	1.7	.	7	2	9	2
GS25	SW00317EG	950516	2035	0.02	0.004	0.006	0.002	1.053	0.051	0.614	0.035	4	1	6	2
GS25	SW00342EG	950628	1549	0.037	0.006	0.029	0.007	0.481	0.029	0.254	0.02	10	2	15	2

EPu-239,240 = Error term for Pu-239,240 analysis; EAm-241 = Error term for Am-241 analysis, etc. Data are preliminary and subject to revision.

D